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Unattended Multiplicity Shift Register (UMSR) User Manual

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Los Alamos
NATIONAL LABORATORY

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1. Introduction

1.1. Purpose

This User Manual is intended to familiarize the user with the Unattended Multiplicity Shift Register (UMSR) and its functions. It includes a description of the UMSR along with setup and operation instructions.

1.2. Definitions and Acronyms

1.2.1. Acronyms

UMSR	Unattended Multiplicity Shift Register
TTL	Transistor to Transistor Logic
HV	High Voltage
LED	Light Emitting Diode
IAEA	International Atomic Energy Agency
RAINSTORM	Real-time And INtegrated. STream-Oriented Remote Monitoring

1.3. References

[1] Parker, R. Klosterbuer, S. “MiniGRAND User Manual”, Los Alamos National Laboratory, LA-UR-99-4400.

[2] Bill Harker, Merlyn Krik, “INCC Software Users Manual”, Los Alamos National Laboratory, LA-UR-99-1291

2. Description

The Unattended Multiplicity Shift Register (UMSR) is the next generation high speed attended and unattended neutron coincidence analysis data acquisition instrument. The UMSR is a specialized pulse counter used primarily to count neutron events originating in neutron detection instruments. While the counter can be used to count any TTL input pulses, its unique ability to record time correlated events and the multiplicity distributions of these events makes it an ideal instrument for counting neutron events in the nuclear fields of material safeguards, waste assay and process monitoring and control.

The UMSR combines the Los Alamos National Laboratory (LANL) simple and robust shift register design with a Commercial-Off-The-Shelf (COTS) processor and Ethernet communications. The UMSR is a direct replacement for existing International Atomic Energy Agency (IAEA) neutron data acquisition instruments such as the Advance Multiplicity Shift Register (AMSR) and JSR-15. The UMSR provides 0V to 2kV programmable High Voltage (HV) bias and both a 12V and a 5V detector power supply output. Serial over USB communications allows the use of existing versions of INCC software. A simple web-browser interface can be used to configure and run the instrument. The UMSR automatically stores data on redundant internal uSD cards and performs an automatic data dump upon insertion of a USB flash drive.

Figure 1. UMSR front and back panels.

3. Specification

Table 1
UMSR Specifications

Physical			Units
Dimensions	h - w – d	50 x 125 x 200	mm
Weight		1.0	kg
Inputs			
Signal AUX1 AUX2 AUX3 (BNC)	TTL Threshold Minimum Pulse Width Minimum pulse pair separation Input Impedance Maximum Count Rate	 0.5 10 20 900 or 50 (jumper selectable) 50	 V ns ns ohms MHz
Power	Voltage Max Power Input Connector	12 (center positive) 4 2.1 ID, 5.5 OD, 10	Vdc W mm
Outputs			
HV (SHV) (Matsusada TC-2P-12)	Range Max current Ripple	0-2000 +/- 10 0.7 10	V mA mV pk-pk
12V (Hirose RM12BRD-3S) Pin1 – 12V Pin2 - Gnd	Range Max current	Filtered input power 2.2	V A
5V (BNC)	Range Max current	5V+/- 0.5 1.2	V A
Communications	Ethernet Serial	10/100/1000 9600, 1 stop, no and no	Mbps BAUD
Programmable Settings			
	Gate Length	0.04 to 1300	us
	Predelay Length	0 to 1300	us
	Longdelay (Fixed)	5234	us
	Accidentals	Standard or Fast	
	Acquisition time	0.1 to $2x10^9$	s

4. Operating Basics

4.1. Connecting the UMSR

4.1.1.Connector Descriptions

Connections to the UMSR are located on both ends of the unit. The power connection is located on one end of the unit, see Figure 2. The input signals, High Voltage (HV) connections and communications ports are located on the opposite end referred to as the signal end.

The main power, 12V, connection is a 2.1mm by 5.5mm by 10mm barrel connector with the center as the positive voltage. The maximum expected current draw is 330mA with no load connected to the 5V and 12V outputs.

Figure 2. UMSR power end.

The signal end of the UMSR provides connections for both the detector and the computer. Power to the detector can be supplied from either the 5V BNC output and/or the 12V three pin circular connector. Bias for the detectors under test is provided from the SHV connector. Four data signal input connectors are also located on this end of the instrument. The “SIG” input is the only shift register input while AUX1 through AUX3 inputs are auxiliary counting channels.

Three USB ports are accessible. The lower right port is for INCC communications over a USB pipe. The user’s computer must have the Silicon Labs CP210X drivers installed to use this port. The USB port under the HV connector is for expert user debug use only. The USB type A connector under the Ethernet jack is for automatic downloading of data to a USB flash drive. The Ethernet port is used to connect to the UMSR’s web interface. The web interface can be used to configure the UMSR, to start and stop the UMSR and to see measurement results.

Blue LED indicators are visible on both sides of the signal end of the UMSR. These LEDs have multiple flash sequences that provide the user with an indication of the UMSR status.

Figure 3. UDCM signal end.

4.2. Operating the UMSR

There are two user interfaces available for the UMSR. The first is the embedded webpage accessed via the UMSR's Ethernet connector. The second is using LANL INCC software. INCC communicates with the UMSR through the micro-USB connection located in the lower right corner.

4.2.1. Embedded Webpage

The UMSR's primary interface is an embedded webpage (or web-browser interface) accessed via the Ethernet port. The user's computer must have a network card on the same subnet as the UMSR. The UMSR's default IP address is 192.168.0.20 but this address may be changed by the user. The web page contains fields for displaying data values, configuration values and buttons to control the UMSR's operation, see Figure 4. When the UMSR is acquiring data the web page is updated every few seconds; when it is stopped the web page is updated only when Submit or Start is clicked.

The webpage displays five windows,1) Setup, 2) Settings, 3) Results, 4) State, and 5) Multiplicity.

The Setup window is used to configure and to start the instrument. When *Stop* is pressed a setup section is displayed and the user can then change parameters as needed. Values for attended mode, accidentals mode, acquire time, high voltage, gate width and pre-delay can then be entered and submitted to the device. The acquisition must be stopped before new configuration data can be entered. Clicking the Submit button will cause changed values to be written into the instrument's configuration file, an entry will be written into the log file, and the new values will be used when the next acquisition is started.

The *Start/Stop* button controls the state of the UMSR. When the UMSR is not acquiring (stopped), the setup table is displayed and configuration data can be changed. Clicking the *Start* button causes the UMSR to begin acquiring data and removes the setup table. Clicking *Stop* causes the current acquisition to terminate, saves the data acquired and restores the setup table.

NOTE: The user must click Submit before selecting *Start* for the updated configuration data to be used.

The Settings window displays the settings that the instrument is using for the current measurement. The Results window displays the reals plus accidentals sum, the accidentals sum as well as the total counts detected on each of the four inputs. The State window displays status information about the instrument including the HV output, the Unit ID#, the software version, FPGA firmware version, a unique serial number, temperature, humidity and a status code. The Multiplicity window displays 1024 multiplicity orders for both the reals plus accidentals histogram data as well as the accidentals histogram data.

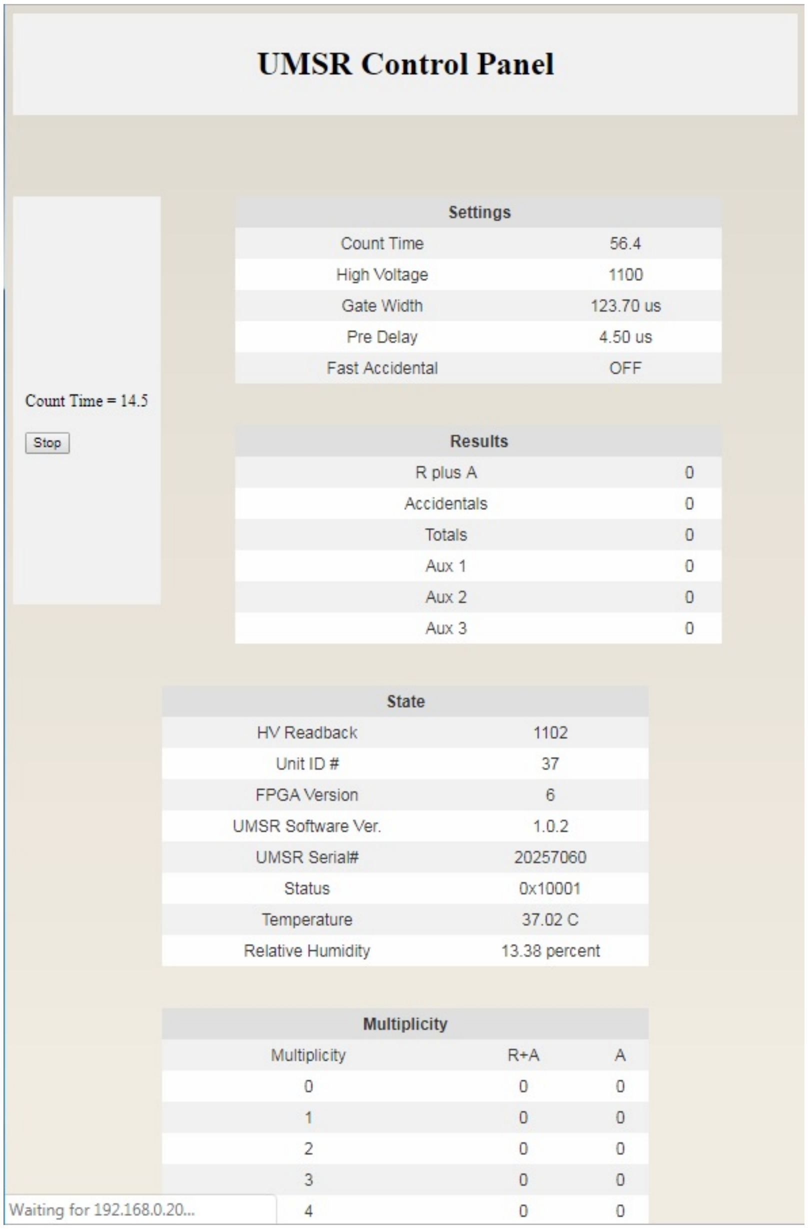

Figure 4. Embedded webpage

4.2.2. INCC

The UMSR's communication protocol was developed such that the UMSR is a drop in replacement for existing neutron analysis instruments, i.e. the AMSR. The UMSR will work with existing LANL INCC software. Detailed instructions on how to use INCC are described in the INCC Software User's Manual, LA-UR-99-1291. Connect the computer running INCC to the lower right micro-USB port. The communications settings are 9600 BAUD, eight data bits, no parity and one stop bit (9600 8-N-1). INCC should be set to AMSR shift register type under the measurement parameters window. The commands that are recognized by the UMSR are listed in the appendix C.

4.2.3. Data Storage

Measurement data is written to both an ISR and a CSV data file after each acquisition. ISR and CSV files are stored by month in the /home/rms/data directory along with a CRC file. The CRC file contains header information and a running crc number for each record that is stored in the ISR data file. Comparisons can be made to make sure that the data in the ISR file is correct.

4.2.3.1. CSV file description

Each line in a csv file contains one run of data. The format of the line is:

- Date and Time
- Instrument ID number
- Temperature (degrees C)
- Humidity (% relative humidity)
- Instrument unique serial number
- Input current (mA)
- Input Voltage (V)
- Totals (counts)
- Aux1 (counts)
- Aux2 (counts)
- Aux3 (counts)
- Accidentals (counts)
- RPLUSA (counts)
- Acquire Time (s)
- Status
- High Voltage (V)
- Gate Width (us)
- Pre Delay (us)
- 1024 data points of Accidental multiplicity orders (counts)
- 1024 data points of Reals plus Accidental multiplicity orders (counts)

For example:

```
2018-12-20T11:51:10+0000     37      39.03   6.57     20257060       794.2    12.1     1860
        0        0        0        13      86      30       135168 1601   128      4.5      1847
        13       0 ……..
```

4.2.3.2. ISR file description

ISR files are the binary data files and are produced to be compatible with older software analysis tools, i.e. MIC. The file begins with one header record and continues with data records until the end of the day at which time a new file is created. The format is:

Record 1: Header

4 ASCII bytes - size of header that follows this field (71)
5 ASCII bytes - not used
3 ASCII bytes – MIC version number assigned (206)
3 ASCII bytes – UMSR unit ID #
3 ASCII bytes - year
3 ASCII bytes - month
3 ASCII bytes – day
4 ASCII bytes – ASCII year
4 ASCII bytes – Temperature (degrees C)
4 ASCII bytes – Relative humidity (%RH)
4 ASCII bytes – Input voltage (V)
4 ASCII bytes – Input current (A)
4 ASCII bytes – UMSR board serial number
23 ASCII bytes - spare

Record 2-n: 54 byte data records for each data acquisition
4 byte unsigned int - julian time, date of data acquisition
2 byte unsigned short int - status byte
8 byte double – Totals 1 Count
8 byte double – Aux 1 Count
8 byte double – Aux 2 Count
8 byte double – Reals + Accidentals Count
8 byte double – Accidentals Count
8 byte double – Elapsed Time in 1/10 sec increments

4.2.4. Rainstorm Compatible Data

In order to operate with the IAEA RAINSTORM, the UMSR stores its data into a set of files in a well-defined location. The root for the files is the directory /home/rms, where rms refers to Remote Monitoring System. The UMSR operating software makes use of three directories below /home/rms:

- data
- logs
- cfg

Data

The data directory contains a directory for each month that the UMSR acquires data. In each month directory is a day file containing all the data acquired during acquisitions that began on that day. Day files include a csv file that may be read using Excel.

Logs

The logs directory contains a directory for each month of operation. In each directory is a file that contains all the log messages for that month. Each log file contains a record of when the individual program started up or terminated, as well as other information specific to the programs. For example, the instrument writes a log entry each time that the acquisitions are stopped or started; the instrument also notes when the configuration has been changed and what the changes were. Error and other informational messages are also logged. The log files can be viewed in Excel or any text editor. Each entry in the log file contains a timestamp, an indication of which program wrote the entry and the informational text associated with the entry.

Cfg

The cfg directory contains one file that contains the configuration information for the UMSR. This file will be created and set to defaults if the file is not present when the UMSR starts, otherwise it is modified by the UMSR as the user changes the UMSR's configuration.

4.3. General Settings and Features

4.3.1.Serial Communications

The UMSR communicates via serial over USB communications using the micro-USB connector. Silicon Labs Virtual Com Port (VCP) drivers must be loaded onto the user's computer to recognize the UDCM's micro-USB port as a virtual com port. The drivers, CP210x USB to UART Bridge VCP drivers, can be found on Silicon Labs website:

http://www.silabs.com/products/mcu/pages/usbtouartbridgevcpdrivers.aspx.

After installing the drivers and connecting the USB cable, the virtual serial port for the UMSR can be found by opening the computers Device Manager window and scrolling down to the COM ports.

4.3.2. Front Panel Status LEDs

The UMSR has two blue LEDs that are located inside the front panel on the signal end that flash to inform the user of the status of the instrument.

Table 2
Front Panel LED Flash Description

LED blink rate	Description
0.2 Hz	The instrument is running its software but no acquisitions are taking place.
0.5 Hz	The instrument is acquiring data.
2 Hz	Data is being dumped to the USB memory device. When the rate returns to 1 Hz the memory device may be removed.

4.3.3. Automatic USB Flash Drive Data Dump

The UMSR copies all files from the instrument to a USB memory device when a device is inserted into the USB type A socket. The UMSR sleeps for five seconds, then wakes up and looks for the presence of a USB memory device. When this occurs, the UMSR sets the front panel status LED blink rate to 2 Hz and then copies all files from the /home/rms/data, /home/rms/logs, and /home/rms/cfg directories to the USB device. When the copy operation is complete, the program unmounts the USB memory device and resets the power switch LED blink rate. At this point the USB device may be removed.

The name of the root directory for the copied files is based on the date and time and is formatted as YYYY-MM-DD_HH-MM; for example, 2018-09-09_17-27. Before performing the copy, the program checks for sufficient space on the USB drive for all the data and will not perform the copy if sufficient space is not present.

4.3.4. Configuring the IP address

The UMSR operating system contains a tool called nmtui (Network Manager using a Text User Interface). This tool provides a text interface to configure networking.

1. SSH into the UMSR via a terminal emulator such as putty and an Ethernet cable connected to the UMSR Ethernet jack. Use the current IP address (the default factory IP address is 192.168.0.20).
2. Log into the UMSR as root. Username: root, password: centos
3. Type nmtui <enter>
   a. Select *Edit a connection*
   b. Select *Eth0-config*
   c. Tab down to *Addresses* under IPv4 and edit the IP address leaving the "/24".
   d. Tab down to the bottom of the page and select *OK*
   e. Tab down to *back*
   f. Arrow down to *Quit*
   g. Type reboot

4.3.5. Setting system time

This process should be used to set the instrument time:

1. SSH into the UMSR via a terminal emulator such as putty and an Ethernet cable connected to the UMSR Ethernet jack. Use the current IP address (the default factory IP address is 192.168.0.20).
2. Log into the UMSR as root. Username: root, password: centos
3. Type date -s "DD MMM YYYY hh:mm:ss" <enter> This sets the time.
4. Type hwclock -w <enter> This stores the current system time to the real time clock.

4.3.6. Upgrading firmware and software

Firmware and software reside on both the external and internal uSD cards as well as the flash memory. Therefore when a software or firmware upgrade is required both uSD cards will need to be updated. Major changes that require updating the flash require special tools and are not covered in this procedure. Flash memory upgrades are considered factory upgrades only and the instrument should be sent back to the manufacturer for this upgrade. The following procedure should be followed for in-field upgrades.

Software

1. Place the new *umsr-#.#.#-#.el7.armv7hl.rpm* file as well the new *umsr-debuginfo-#.#.#-#.el7.armv7hl.rpm* file on a computer with installed the Silicon Labs CP210X drivers, see earlier described section on serial drivers.
2. Ensure the user's computer has a client for the SSH-based SFTP protocol such as psftp.exe.
3. Connect an Ethernet cable to the Ethernet port.
4. Connect a micro-USB cable to the debug USB port.
5. Turn on the instrument.
6. Open a terminal emulator and select 115200 baud rate and the appropriate com port. In most cases the computers Device Manager can be used to determine the com port connected to the USMR.
7. Verify that the instrument has booted to the external uSD card by checking that the command prompt includes mmc0 not mmc1 in the name.
8. Logon as root with centos as the password.

9. Connect to the instrument with the sftp client.
10. Copy both .rpm files to the /root directory of the instrument.
11. From the terminal emulator connected to the debug USB port run the following command:

    rpm -Uvh umsr-#.#.#-#.el7.armv7hl.rpm umsr-debuginfo-#.#.#-#.el7.armv7hl.rpm

12. Reboot the instrument and interrupt the boot process. “hit any key to stop autoboot”.
13. Boot to the internal uSD card by running “run sdbootmmc1”.
14. Verify that the instrument has booted to the internal uSD card by checking that the command prompt includes mmc1 not mmc0 in the name.
15. Repeat steps 8 through 11 above.
16. Reboot.
17. Verify that the instrument has booted to the external uSD card by checking that the command prompt includes mmc0 not mmc1 in the name. If not, do the following to force the instrument to boot to the external uSD card:
    a. Reboot and interrupt the boot process. “hit any key to stop autoboot”.
    b. “run clrbootcounts”
    c. Reboot
18. Verify the new software version is running by checking the software version number displayed in the web-browser interface.

Firmware

1. Place the new system.bit.bin file on the user’s computer.
2. Ensure the user’s computer has a client for the SSH-based SFTP protocol such as psftp.exe.
3. Connect an Ethernet cable to the Ethernet port.
4. Connect a micro-USB cable to the debug USB port.
5. Turn on the instrument.
6. Open a terminal emulator and select 115200 baud rate and the appropriate com port.
7. Verify that the instrument has booted to the external uSD card by checking that the command prompt includes mmc0 not mmc1 in the name.
8. Logon as root with centos password.
9. Connect to the instrument with the sftp client.
10. Copy both the system.bit.bin file to the /boot directory of the instrument.
11. Reboot the instrument and interrupt the boot process. “hit any key to stop autoboot”.
12. Boot to the internal uSD card by running “run sdbootmmc1”.
13. Verify that the instrument has booted to the internal uSD card by checking that the command prompt includes mmc1 not mmc0 in the name.
14. Repeat steps 8 through 11 above.

Appendices

A. Technical Support

For technical support contact:

LANL : Matt Newell 505 667 1327
LANL : Dave C. Jones 505 667 0438

B. Troubleshooting

Table B.1
Troubleshooting Guide

Problem	***Possible Cause***	***Solution***
Does not turn on.	1. Processor did not boot correctly	1. Cycle power to the instrument.
Does not communicate over Ethernet	1. User's network card not on correct subnet. 2. UMSR's IP address not set correctly	1. Check the computers network card setup. Change IP address subnet as necessary/ 2. Check the UMSR IP address.
Does not communicate over the micro-USB line	1. Drivers not properly installed. 2. Wrong COM port selected.	1. Reinstall USB drivers (see USB operations section). 2. Select the correct COM port.
No pulses reported	1. Instrument cables not connected properly 2. HV bias not applied.	1. Check input cables for proper connection and proper connector. 2. Check that HV cable is connected correctly and that HV bias setting is correct.
High Voltage will not turn on	1. Improper load connected to the HV output.	1. Reduce the HV output load (see specifications).

C. UMSR Serial over USB command list

Table C1		
HHMR USB Command List		
Command	**Reply**	**Description**
F x		0 = Turns off High Voltage, 1 = Turns on High Voltage (x is a character)
GR	xx	Get gate width in 250 nanoseconds units (xx is 2-byte binary value such that xx+1 is actual setting)
GW xx		Set gate width (see GR above)
H		Stop
L	xxxx …	Read multiplicity channels (xxxx … consists of 256 4-byte accidentals + 256 4-byte reals+accidentals)
PR	xx	Get pre-delay in 250 nanosecond units (xx is 2-byte binary value)
PW xx		Set pre-delay (see PR above)
R	xxxx …	Read totals, reals+accidentals, and accidentals (xxxx … consists of 3-byte elapsed time, 5-byte totals, 6-byte reals+accidentals, 6-byte accidentals, and 1-byte status (see X below))
S		Start
TR	xxx	Get count time in 100 millisecond units (xxx is a 3-byte binary value)
TW xxx		Set count time (see TR above)
WR	xx	Get high voltage reading in volts (xx is a 2-byte binary value)
WS	xx	Get high voltage set point in volts (xx is a 2-byte binary value in all modes)
WW xx		Set high voltage in volts (see WR above)
X	x	Get status (x is a 1-byte binary value)
		bit 0: 0= stopped, 1 = counting
		bit 1: 1 = not used
		bit 2: 1 = not used
		bit 3: 1 = not used
		bit 4: 1 = Fast accidentals is on
		bit 5: 1 = not used
		bit 6: 1= measurement complete, 0 = not complete
		bit 7: 1= constant voltage on, 0= constant voltage off
Y	xxxxxyyyyy	Read auxiliary scalers (xxxxx=aux1, yyyyy=aux2)
Z		Zero counters

Note: All commands include the ASCII characters indicated above followed immediately by any indicated binary data. There are no spaces implied between the command and accompanying binary data. All data is returned most significant byte first.